Ecohydrology of the Central Plains: An Open Source Approach

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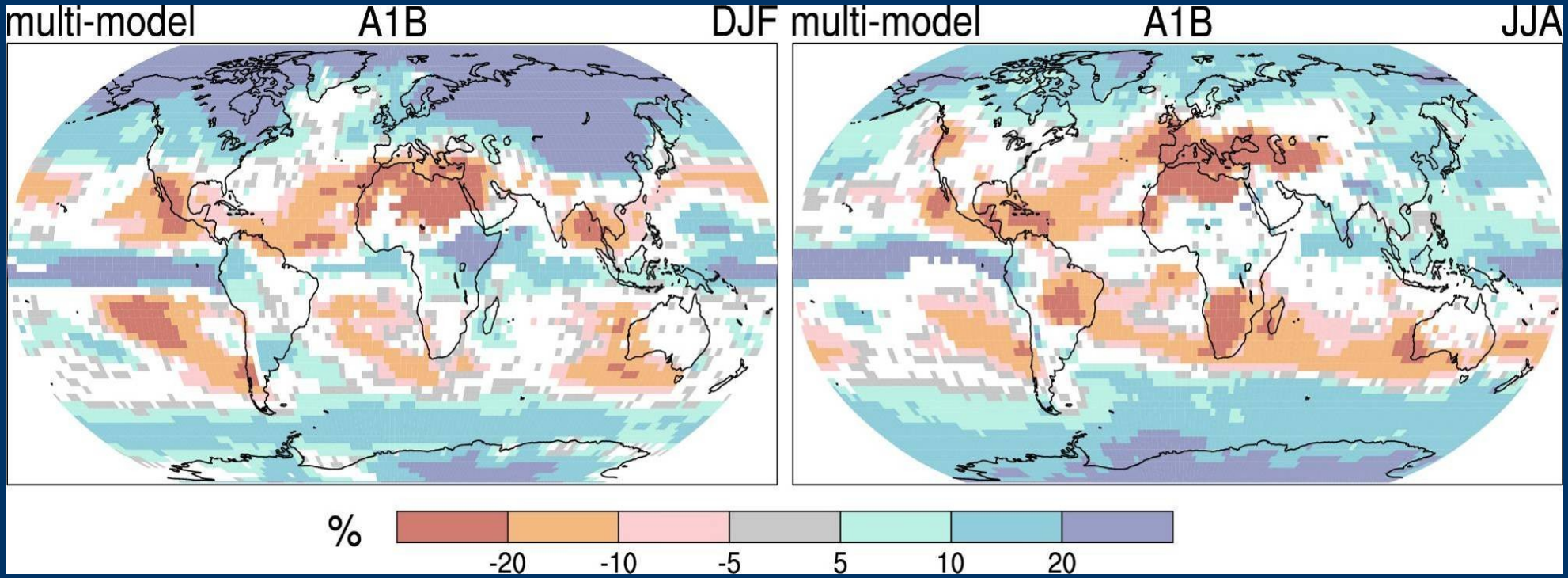
Motivating Questions

- Past: What are the temporal and spatial trends in precipitation and air temperature over the Kansas River Basin and are we observing any vegetative response?
- Future: What are the implications of these changes in relation to different future climate scenarios?
- Future: Can we accurately predict what the future water needs are for the state of Kansas?

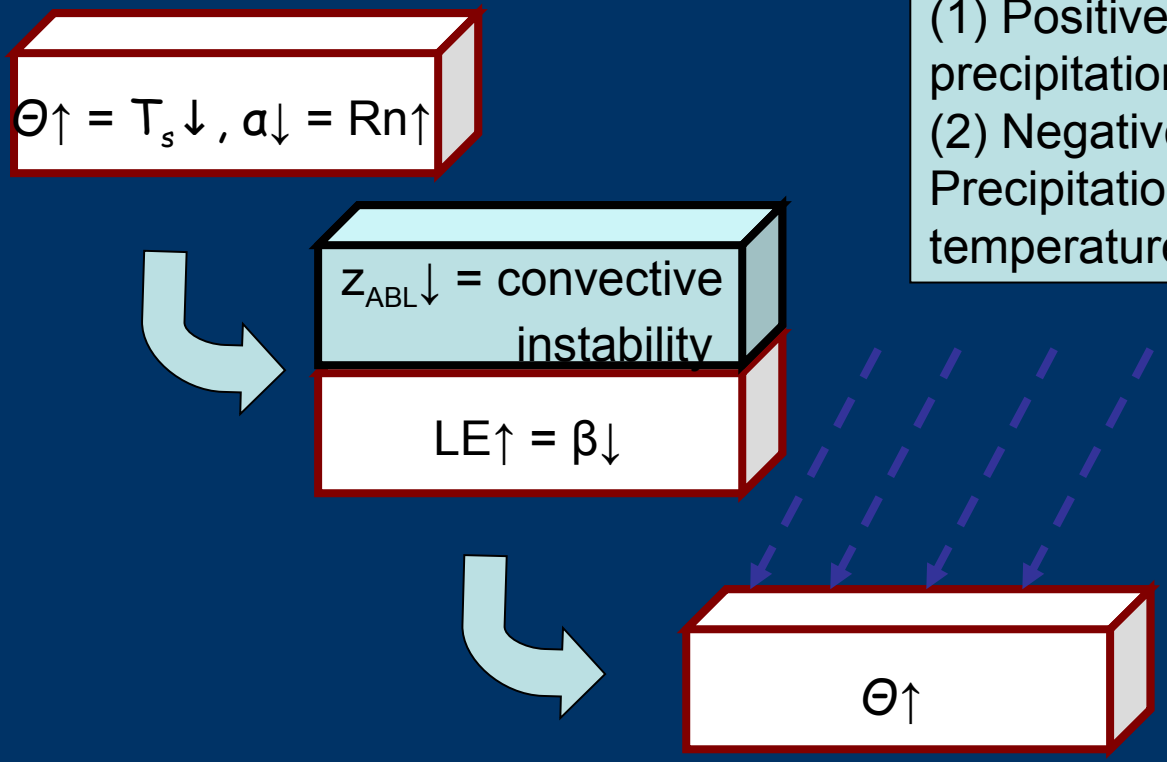
Predicted Precipitation Changes



White areas are where less than two thirds of the models agree in the sign of the change

Surface – Precipitation Feedbacks

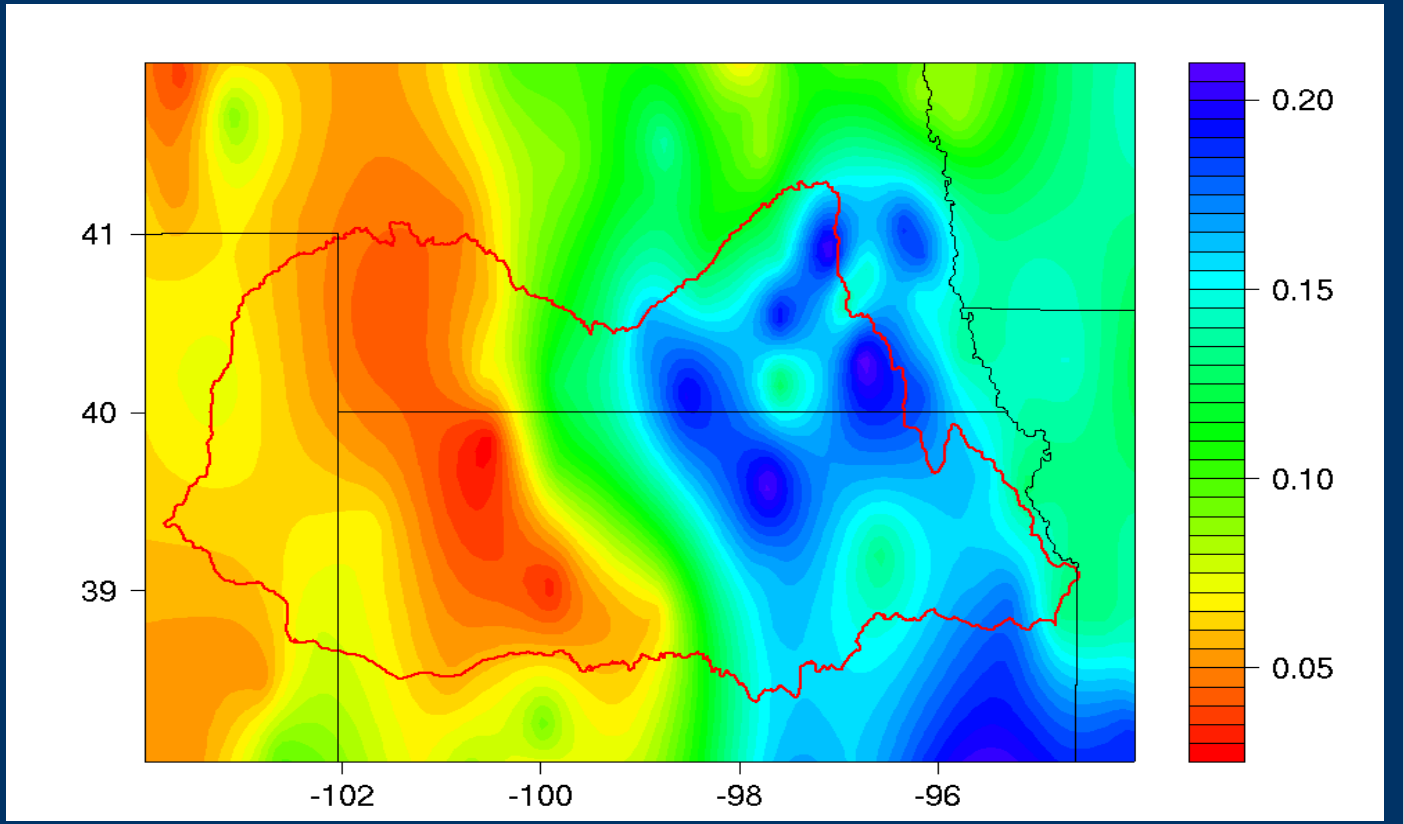
Positive Feedback: Start with positive soil moisture or vegetation anomaly



Leads to:
(1) Positive correlations between precipitation and vegetation
(2) Negative correlation between Precipitation and surface temperature

Interpreted as the reason Why soil moisture tends To have 2 preferential States (wet & dry)

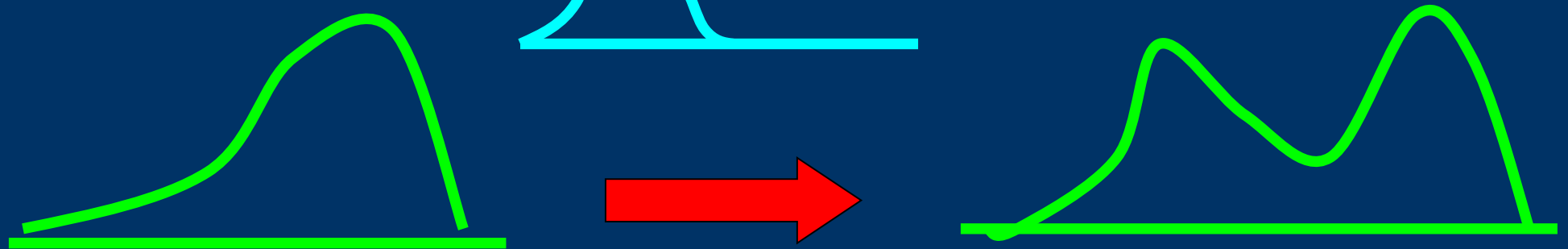
Vegetation - Precipitation Interactions



Vegetation Distribution

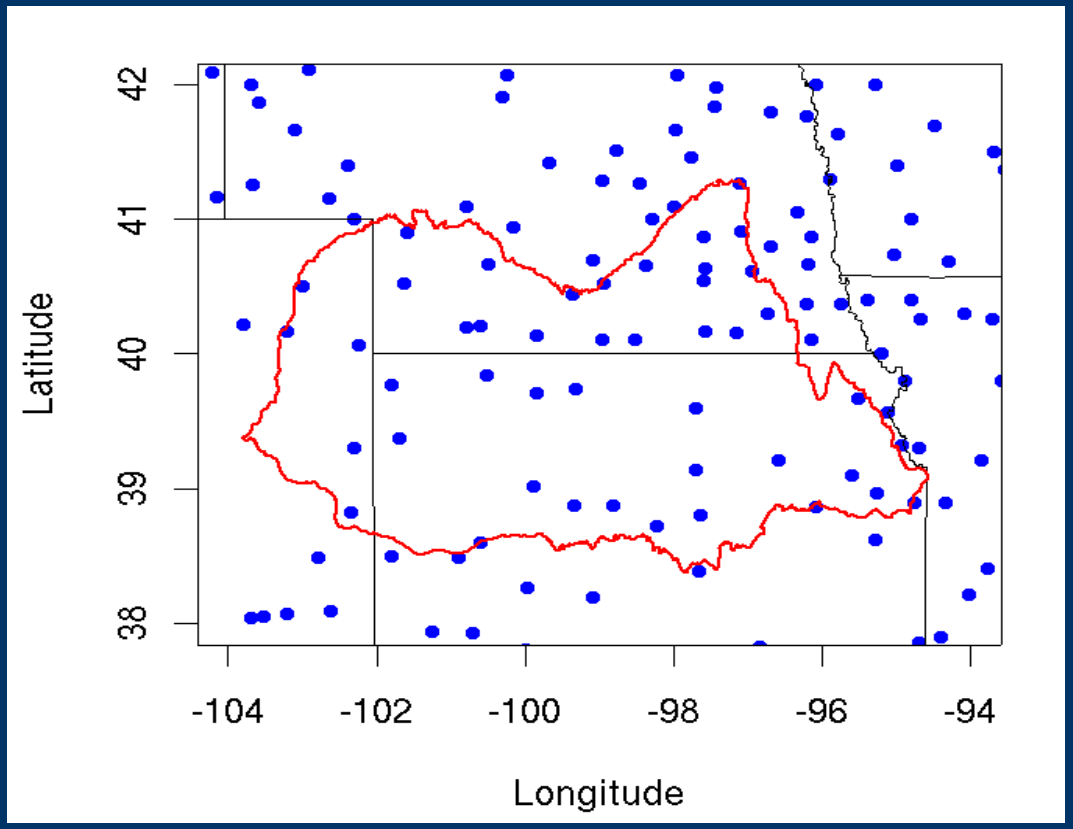
Rainfall Distribution

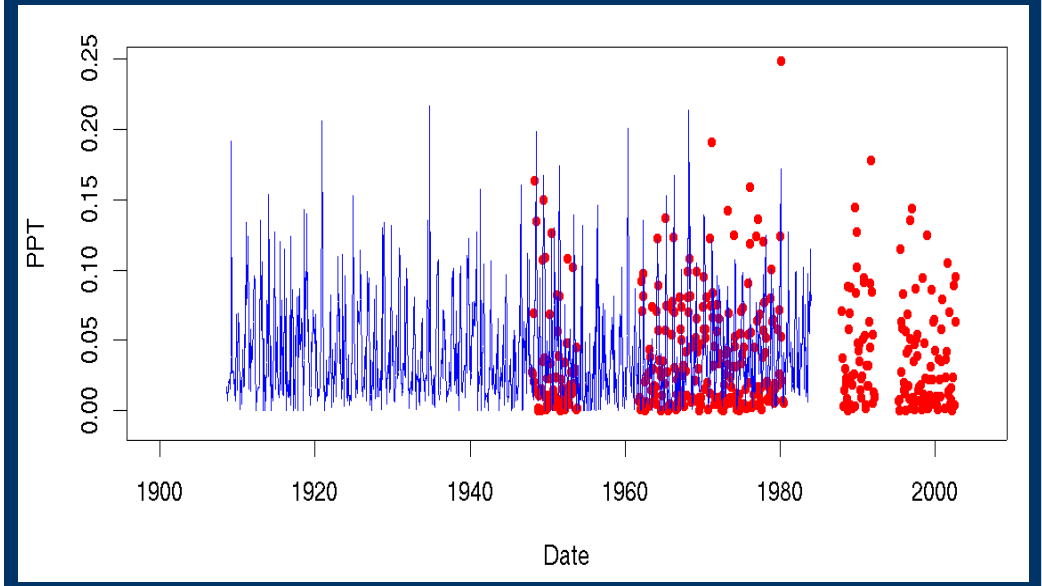
Vegetation Distribution



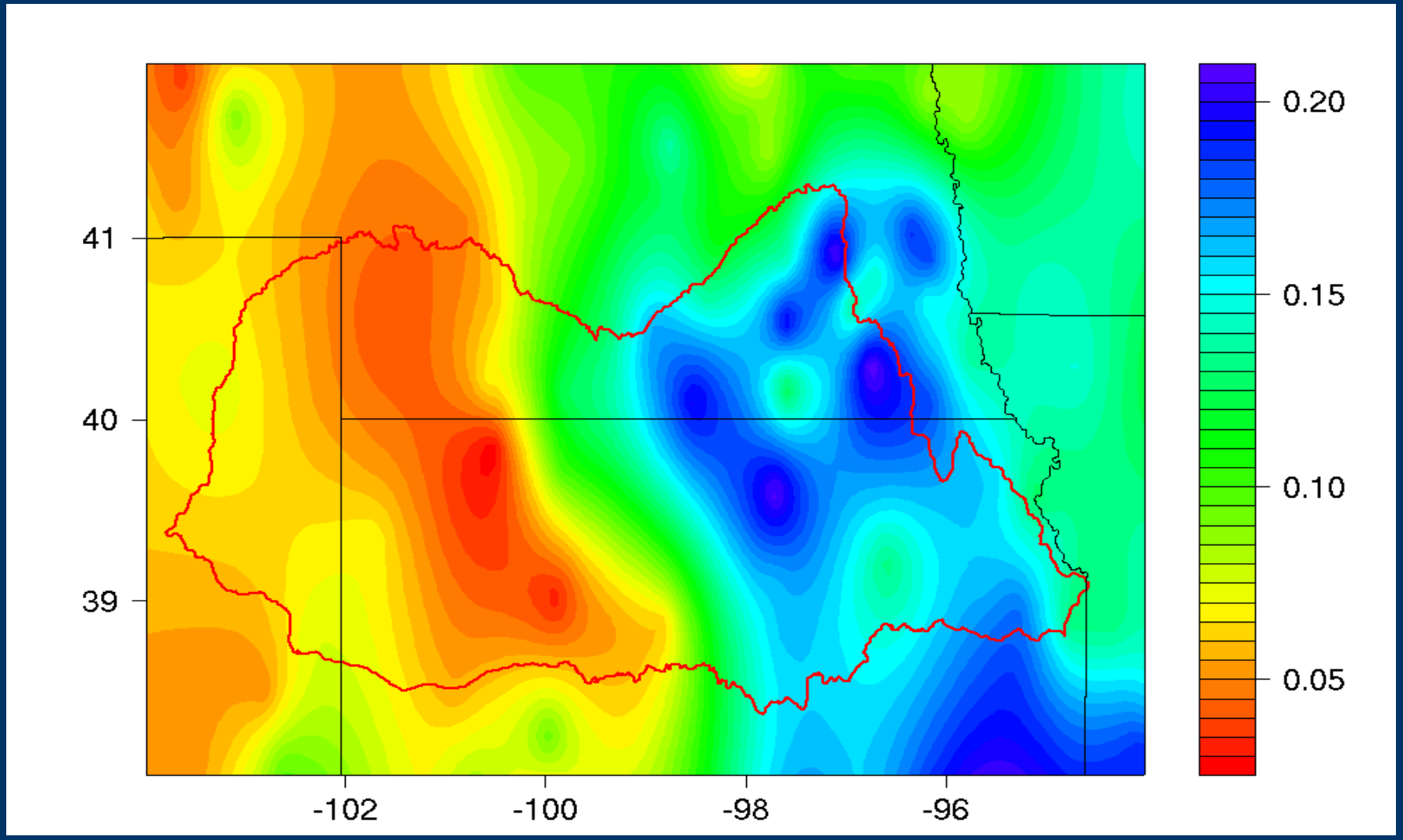
GHCN Data

- Global Historical Climate Network (1850 – 2006)
- Monthly precipitation, min/max/mean temperature

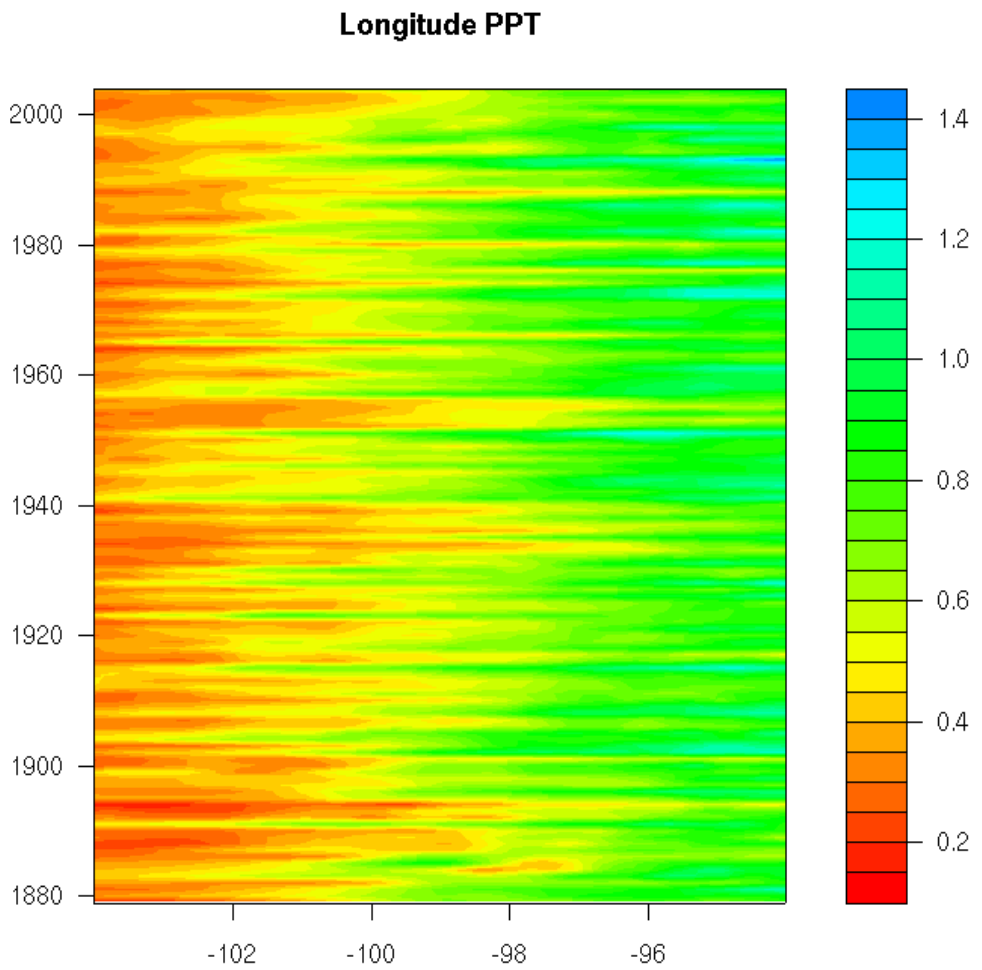


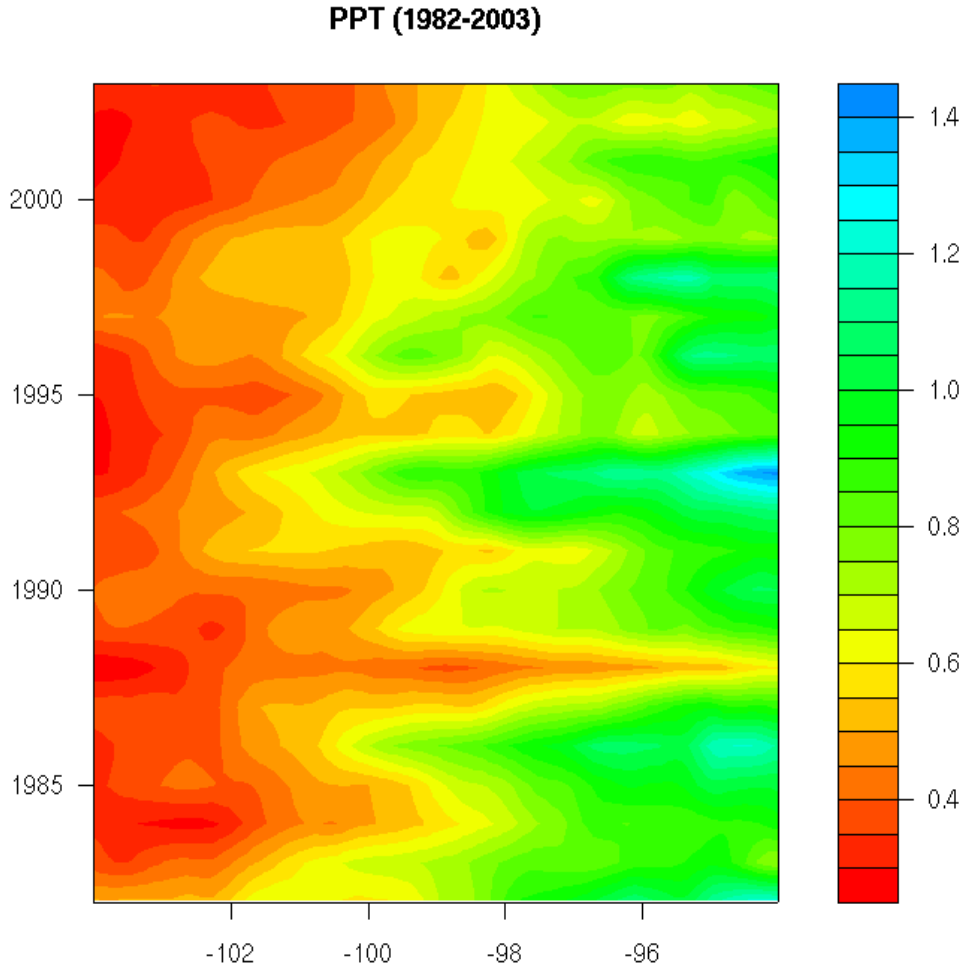


Kriged Monthly Precipitation

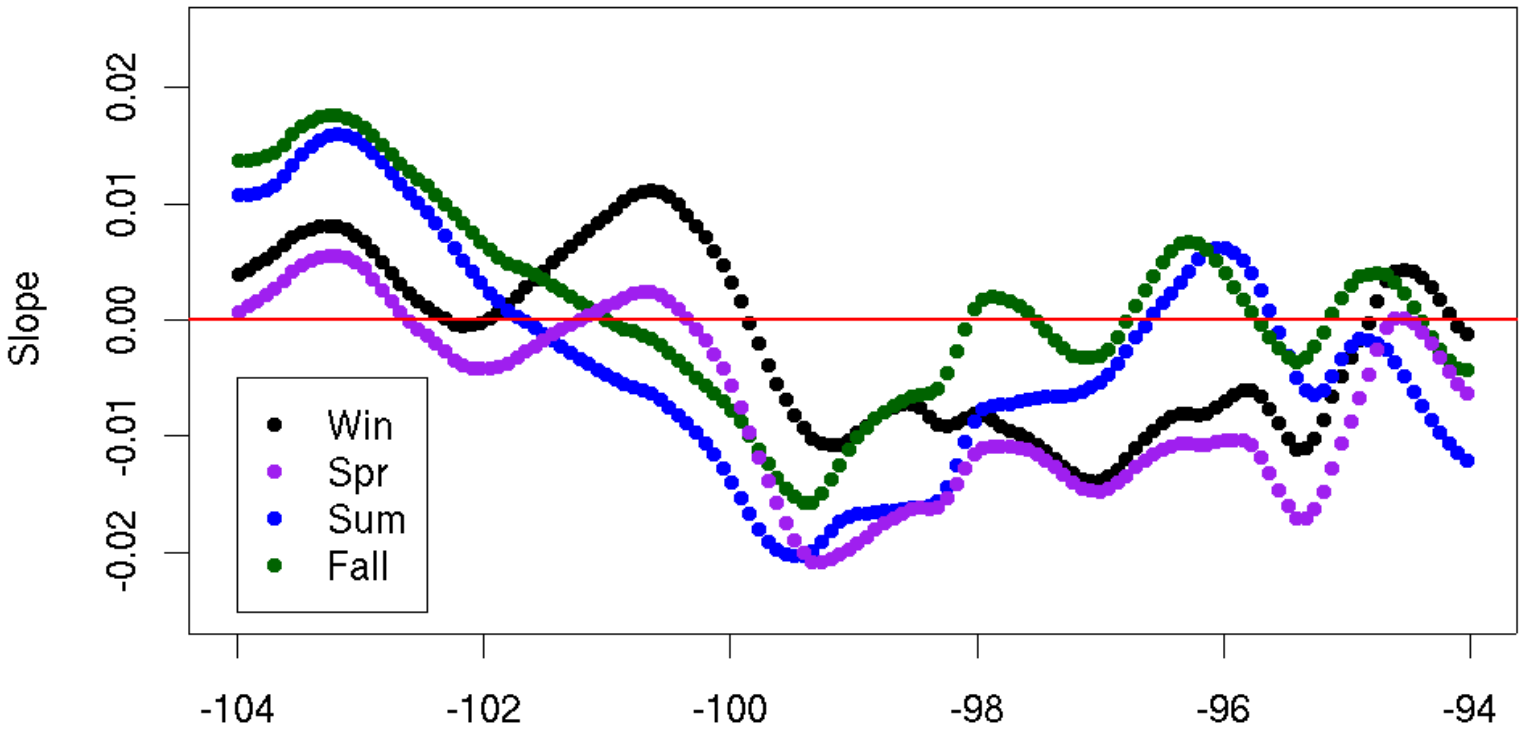


Averaged Precipitation

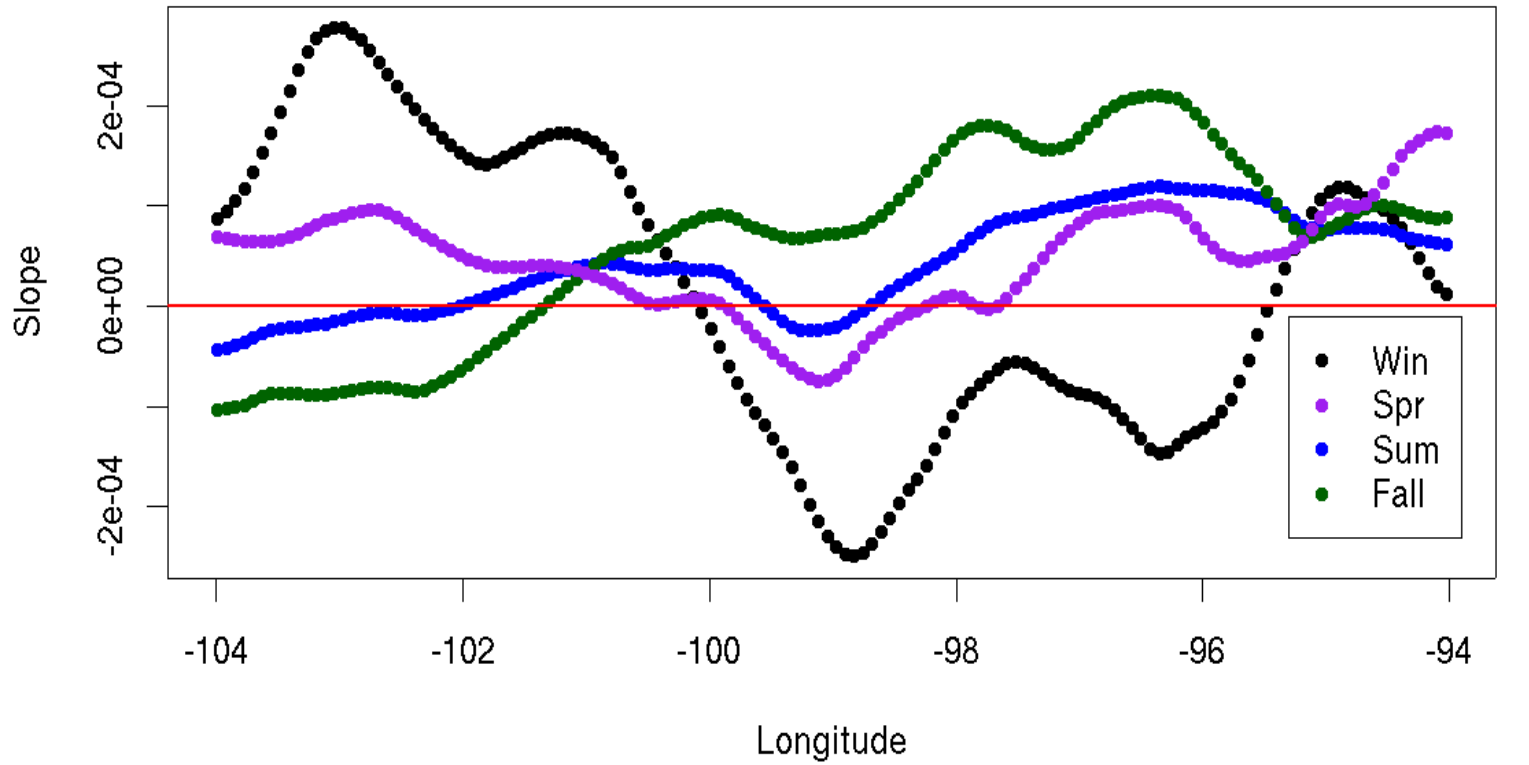




Maximum Temperature Trends

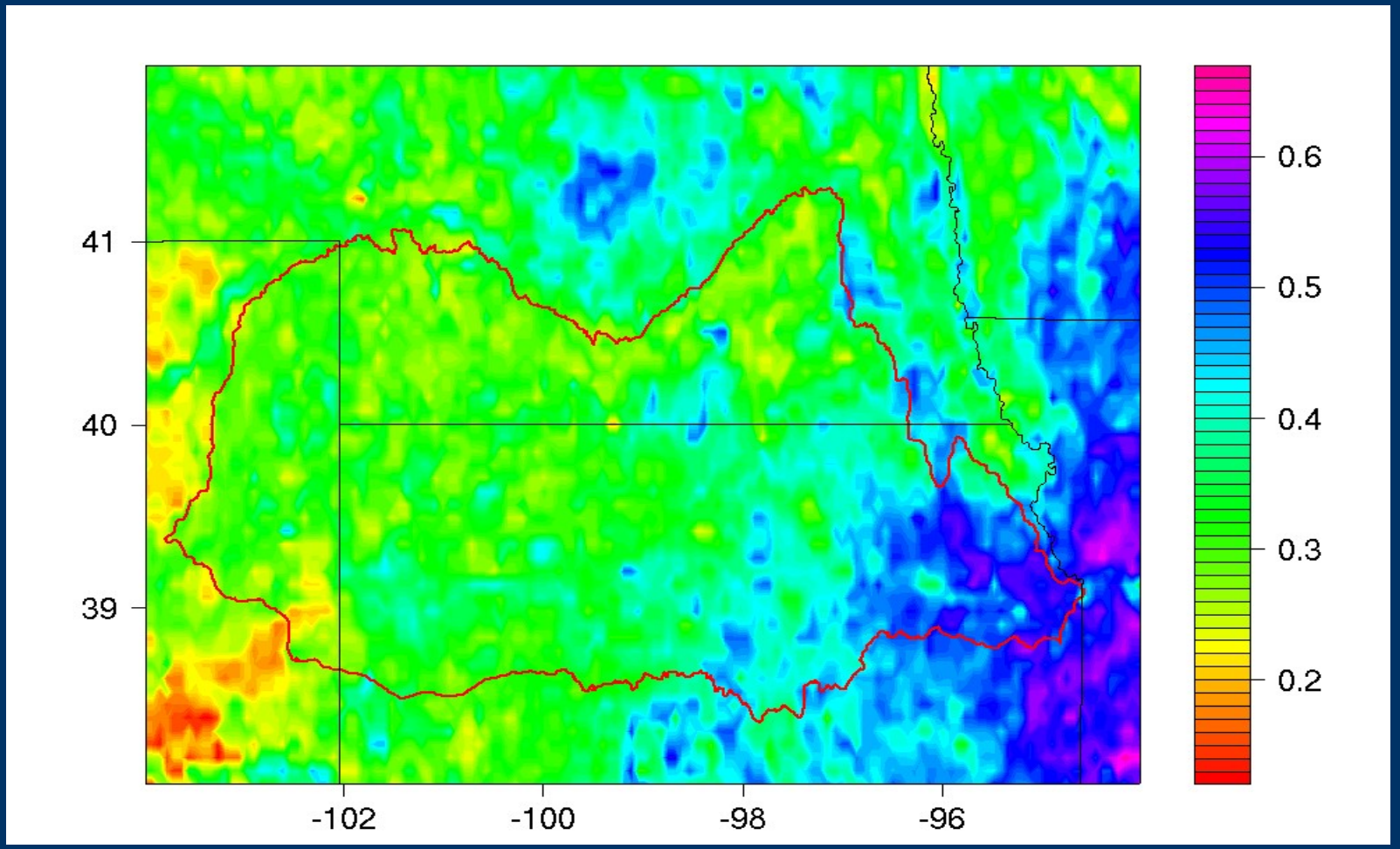


Trends in Seasonal Precipitation

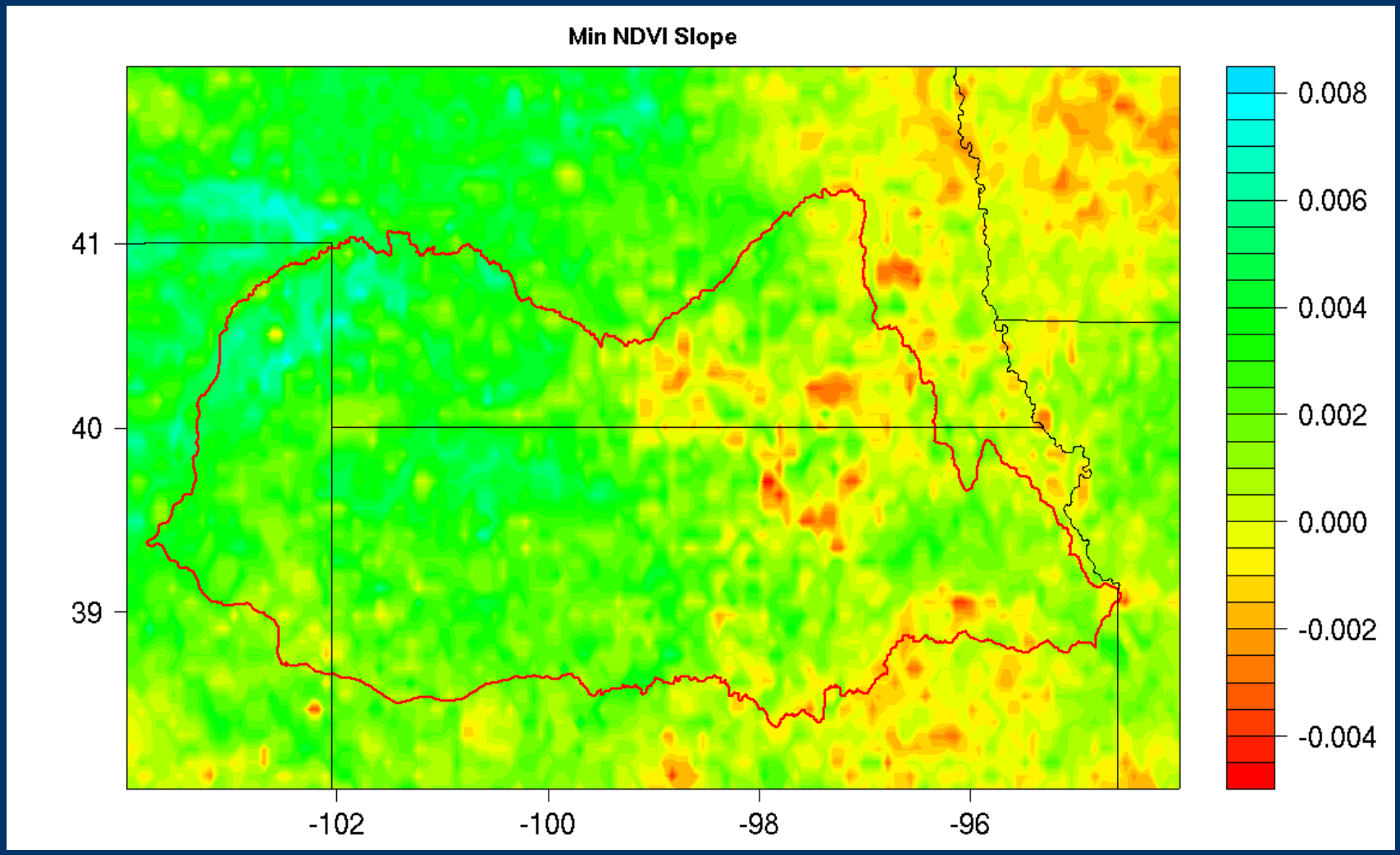


GIMMS AVHRR Data

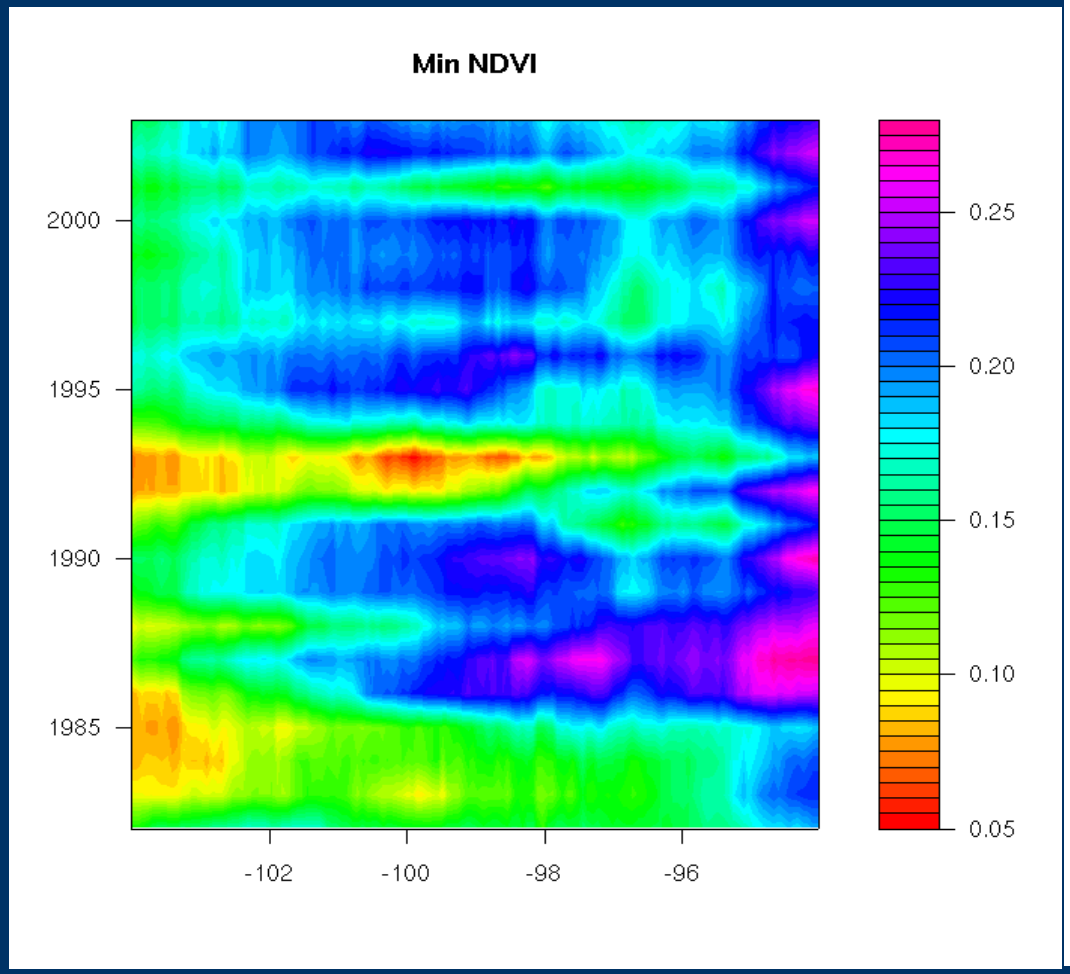
- AVHRR Maximum NDVI composite
- 1982-2003

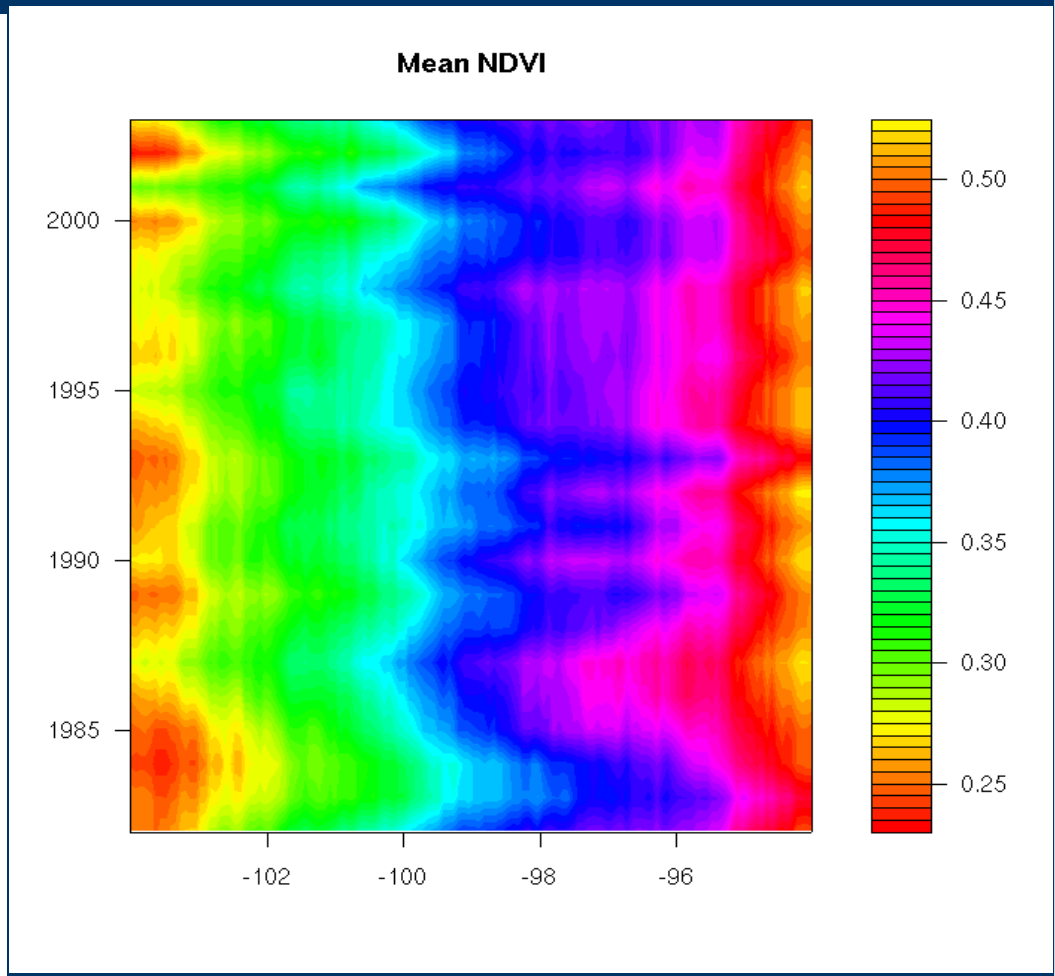


Temporal Trends in Minimum NDVI

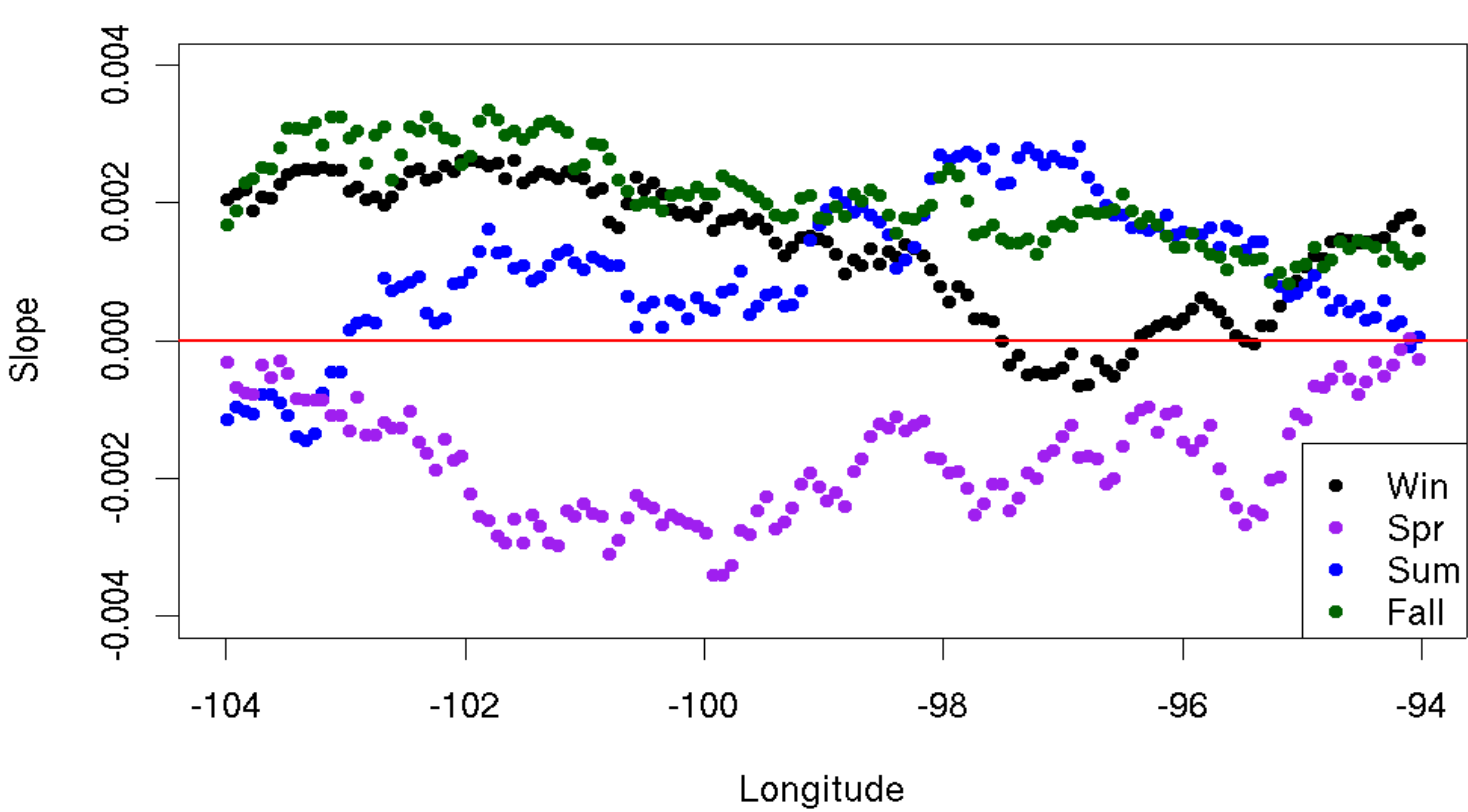


Temporal Trends in NDVI

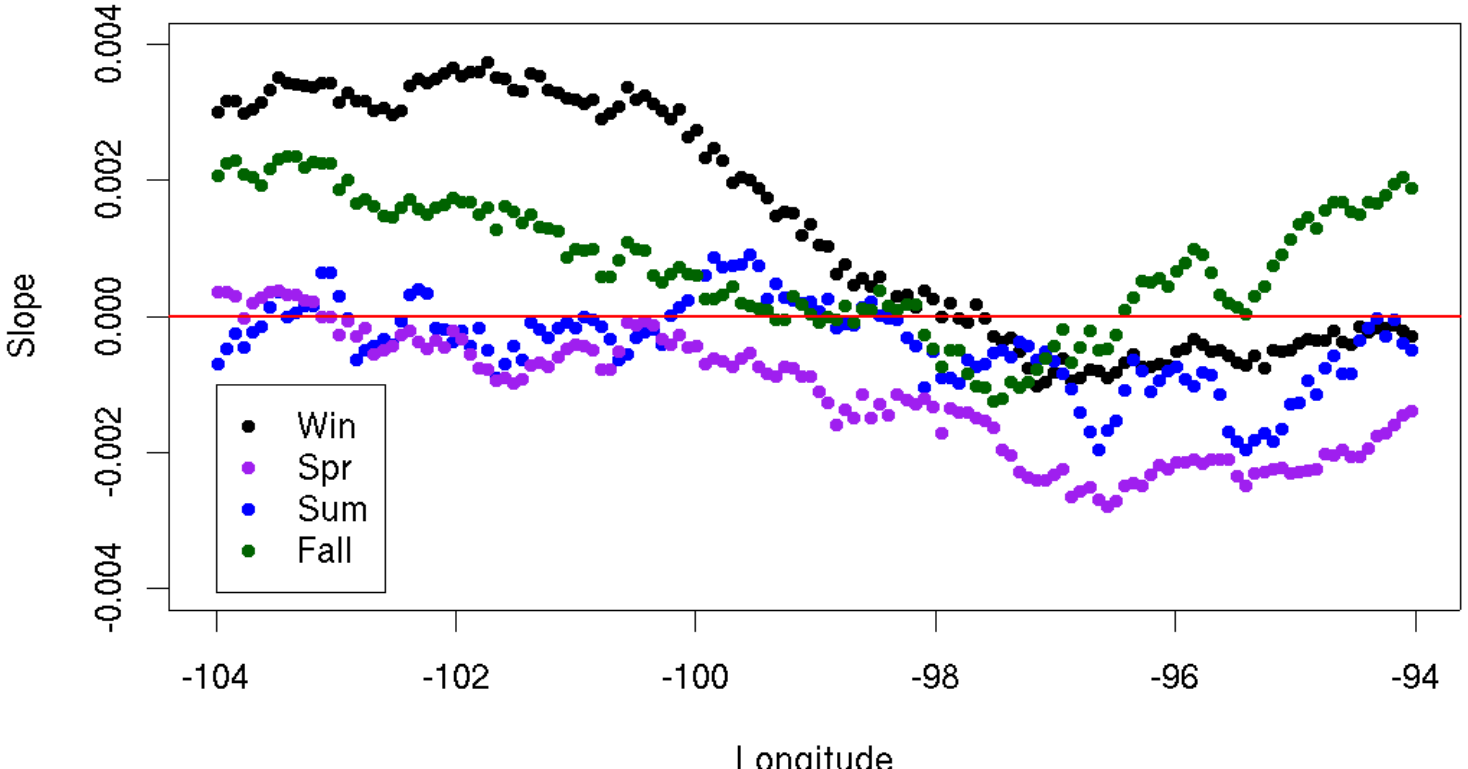


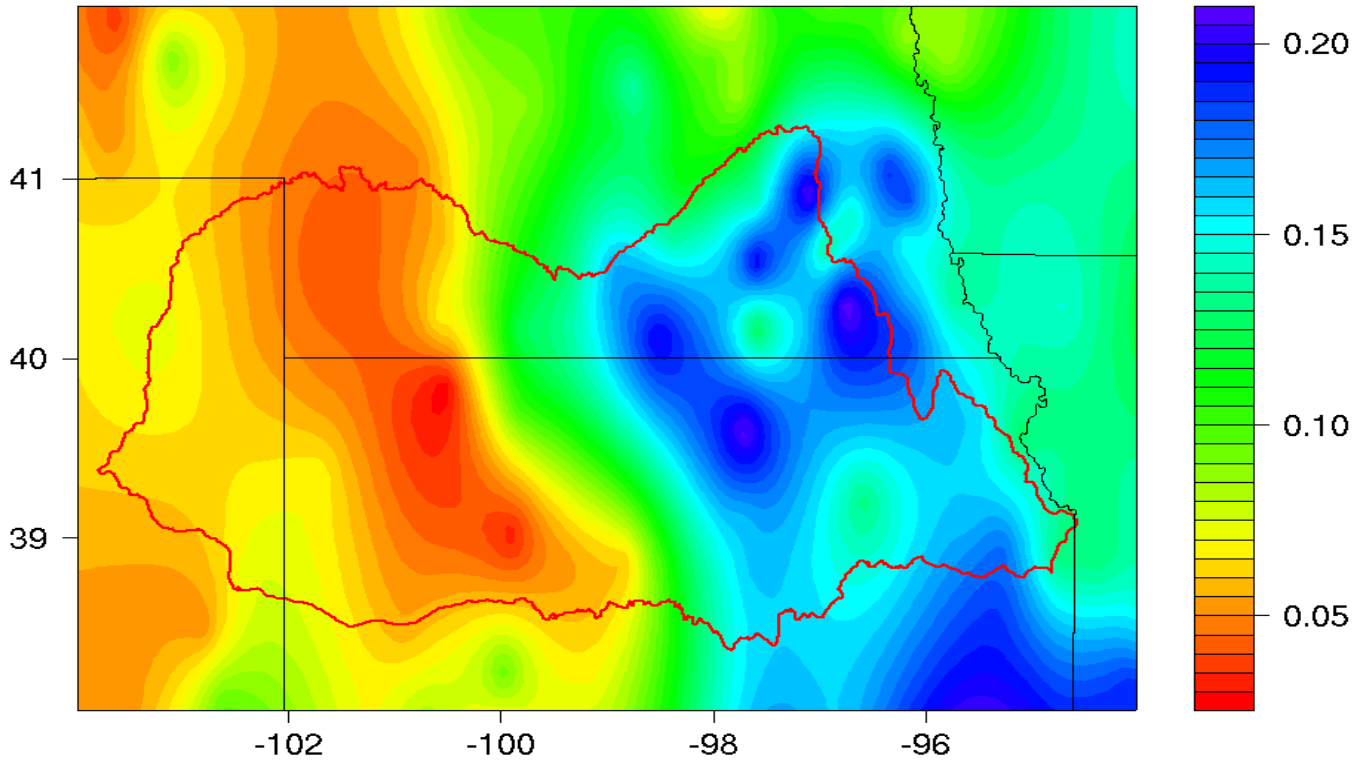


Maximum Seasonal NDVI

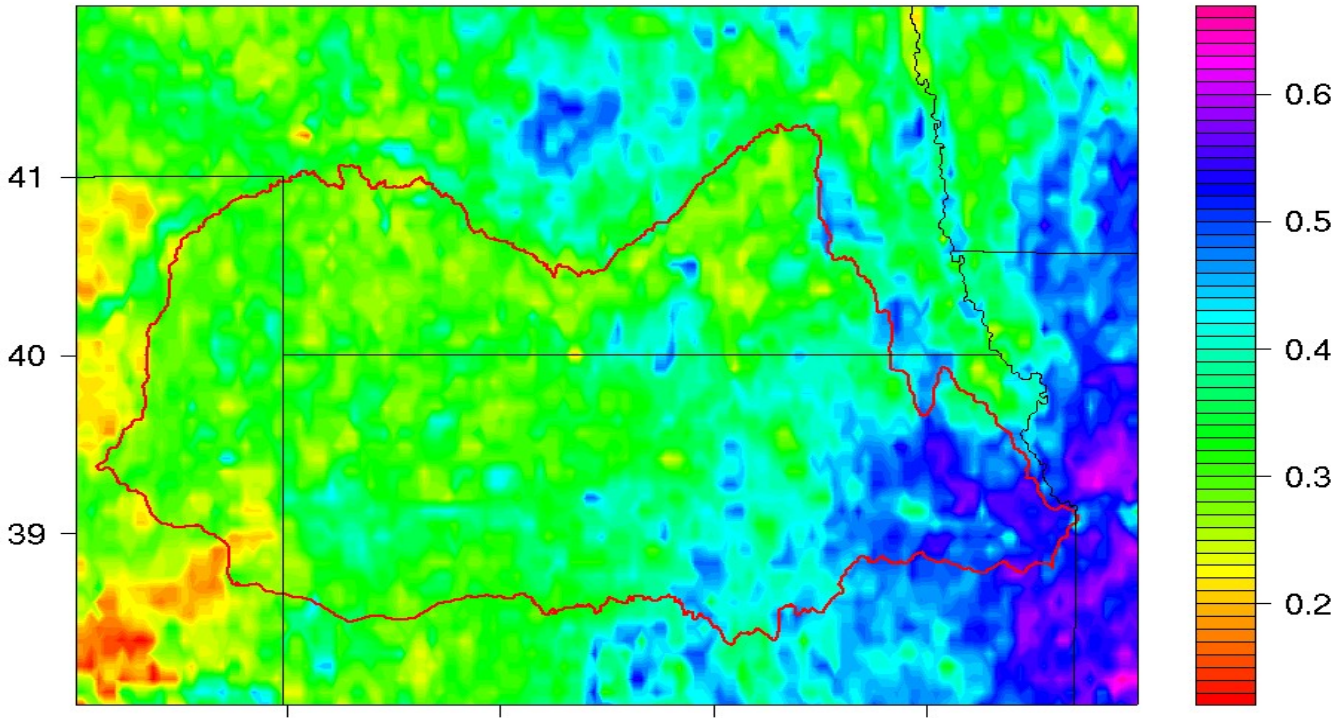


Minimum Seasonal NDVI

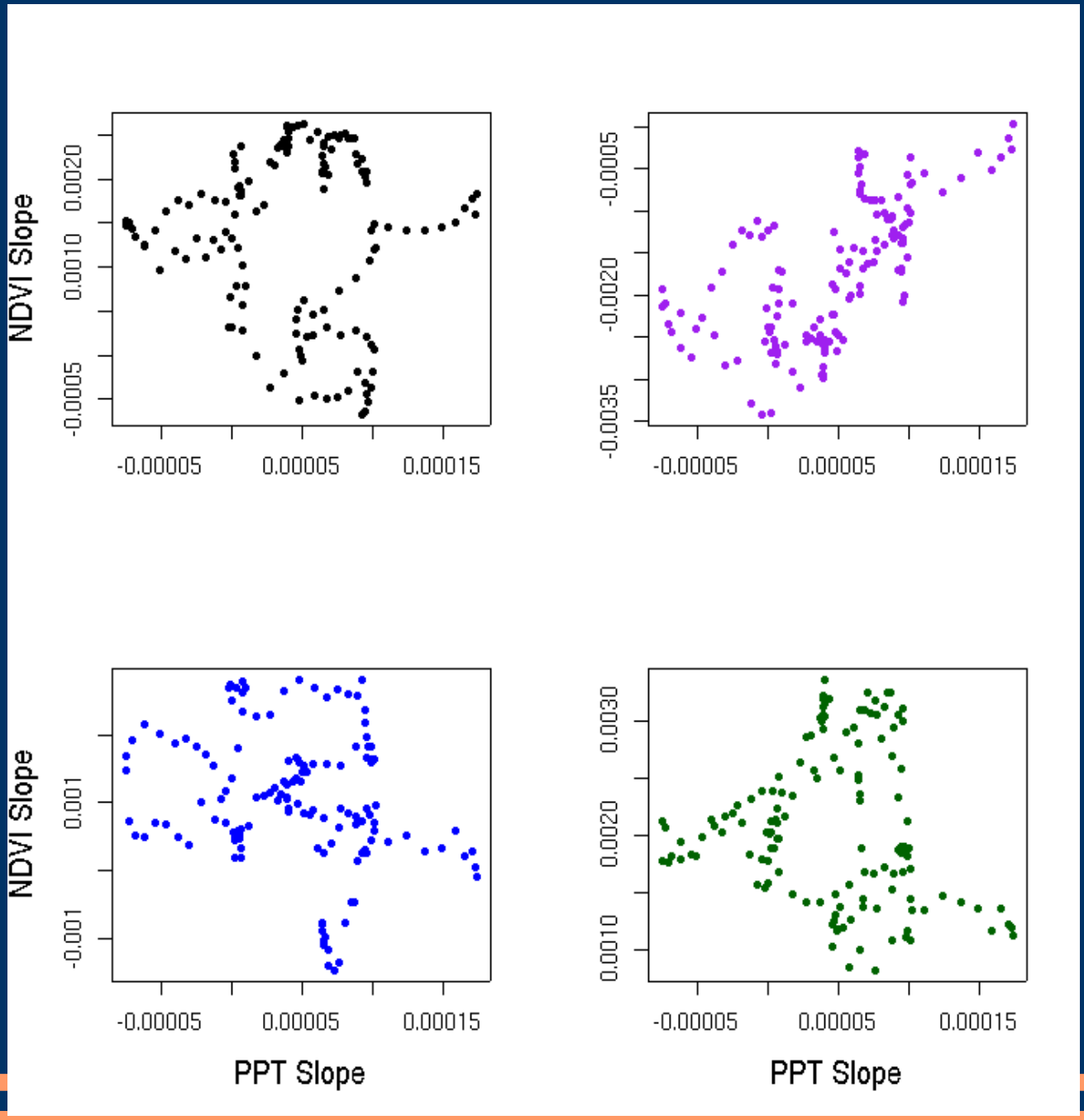




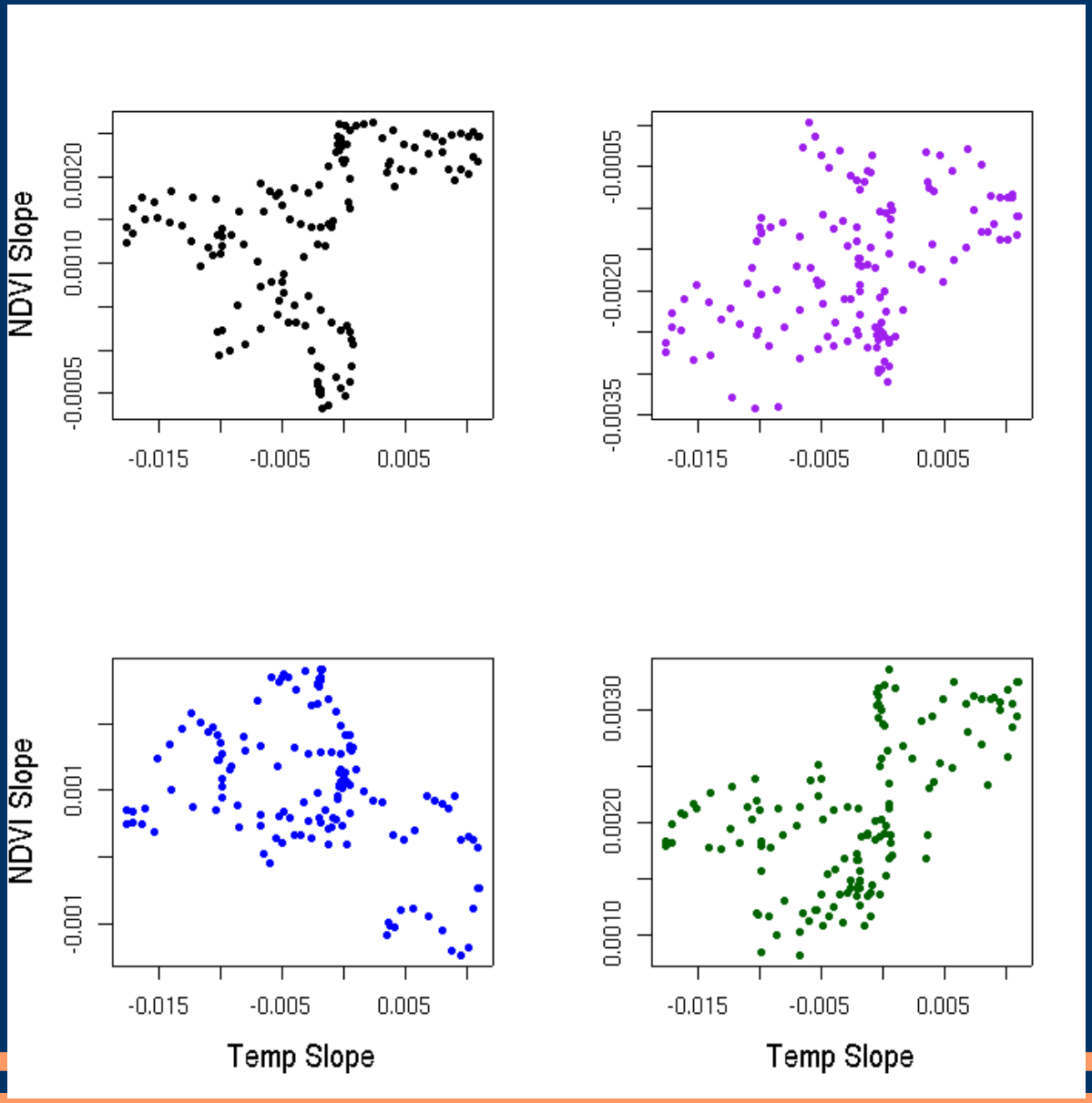
Vegetation - Precipitation Interactions



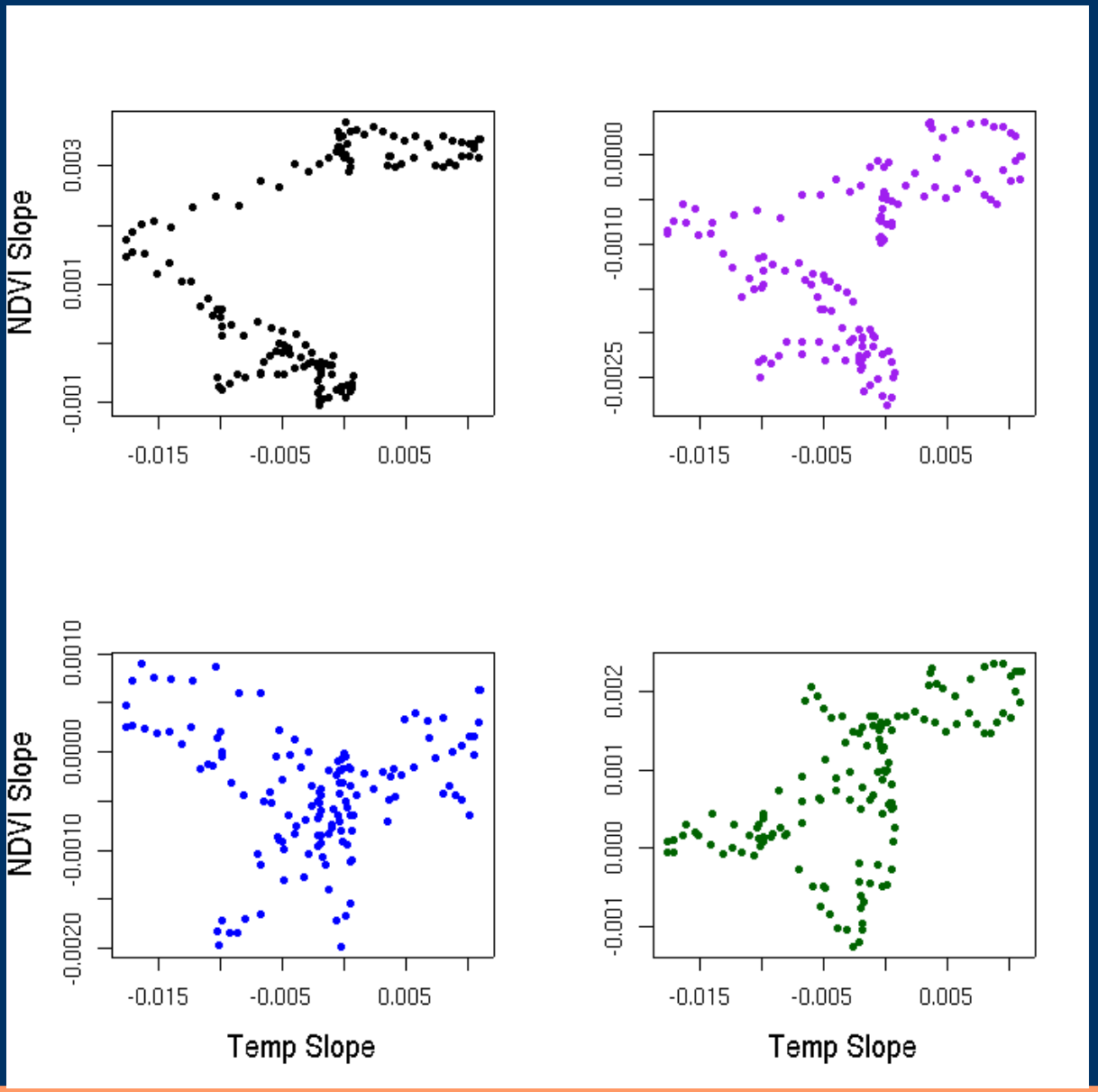
Trends in Spring PPT and Maximum NDVI



Trends in Maximum Spring Temperature and Maximum NDVI



Trends in Maximum Spring Temperature and Seasonal Minimum NDVI



The Road to Predictability: Entropy

- Shannon entropy

$$H = -\sum_{i=1}^{N} p_i \log_2(p_i)$$

Measure of the ‘disorder’ of a data-series

Based on the probability density function:

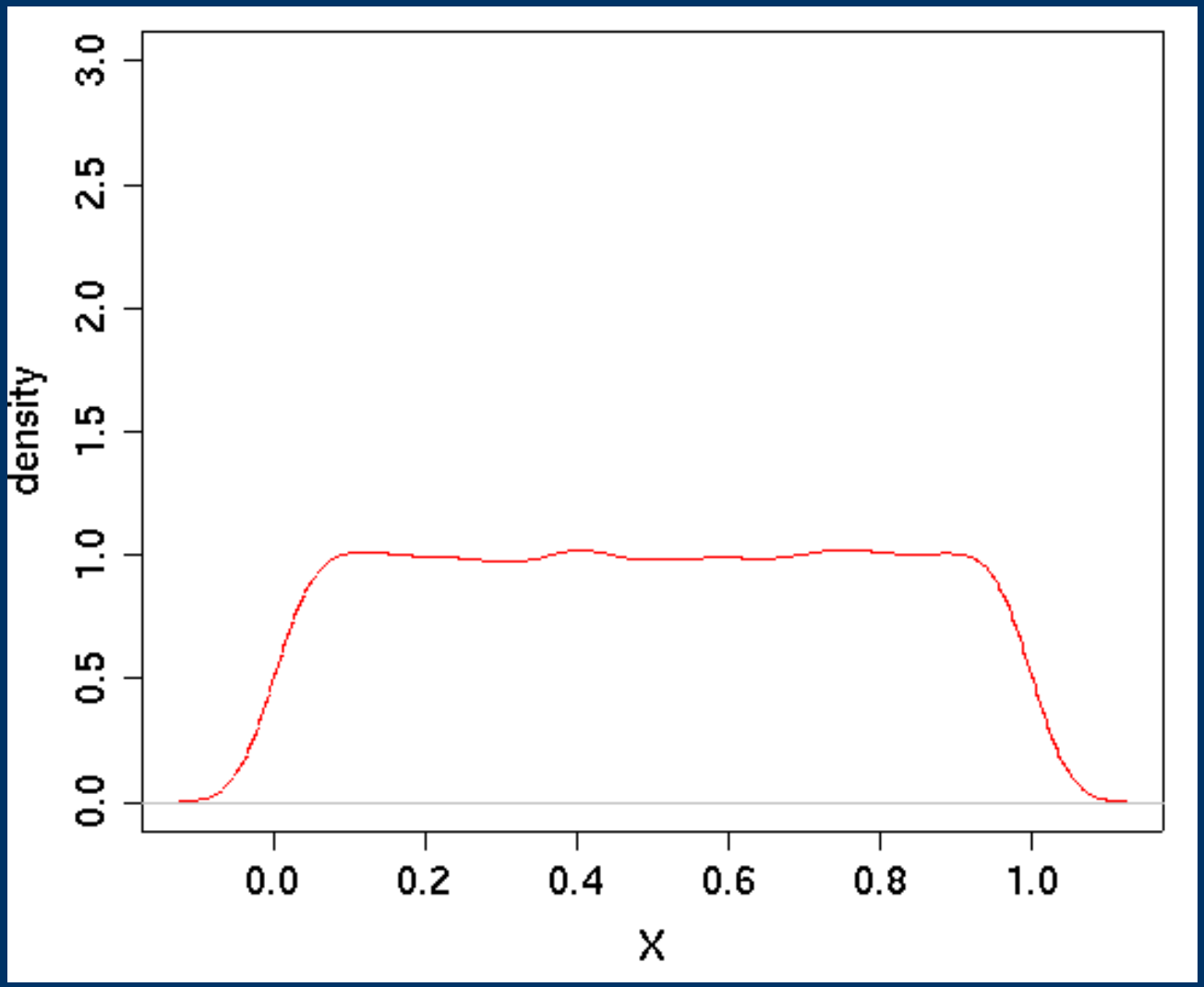
more uniform = more disordered

less information = less predictable

Precipitation Forcing

Imagine an input signal as a uniform pdf

Has a high entropy (low predictability)



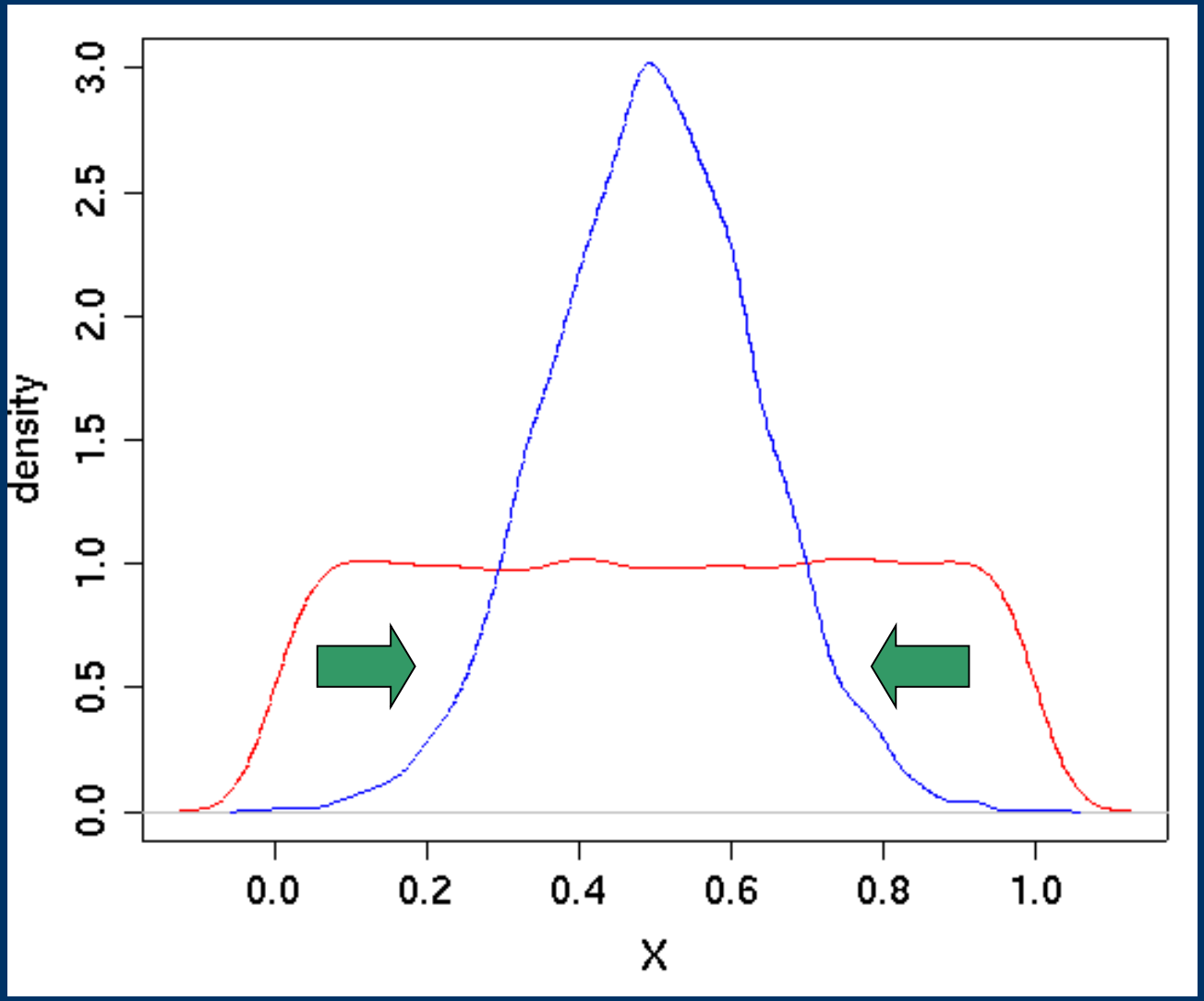
Precipitation Forcing

Imagine an input signal as a uniform pdf

Has a high entropy (low predictability)

Low-pass filtering will reduce the tails

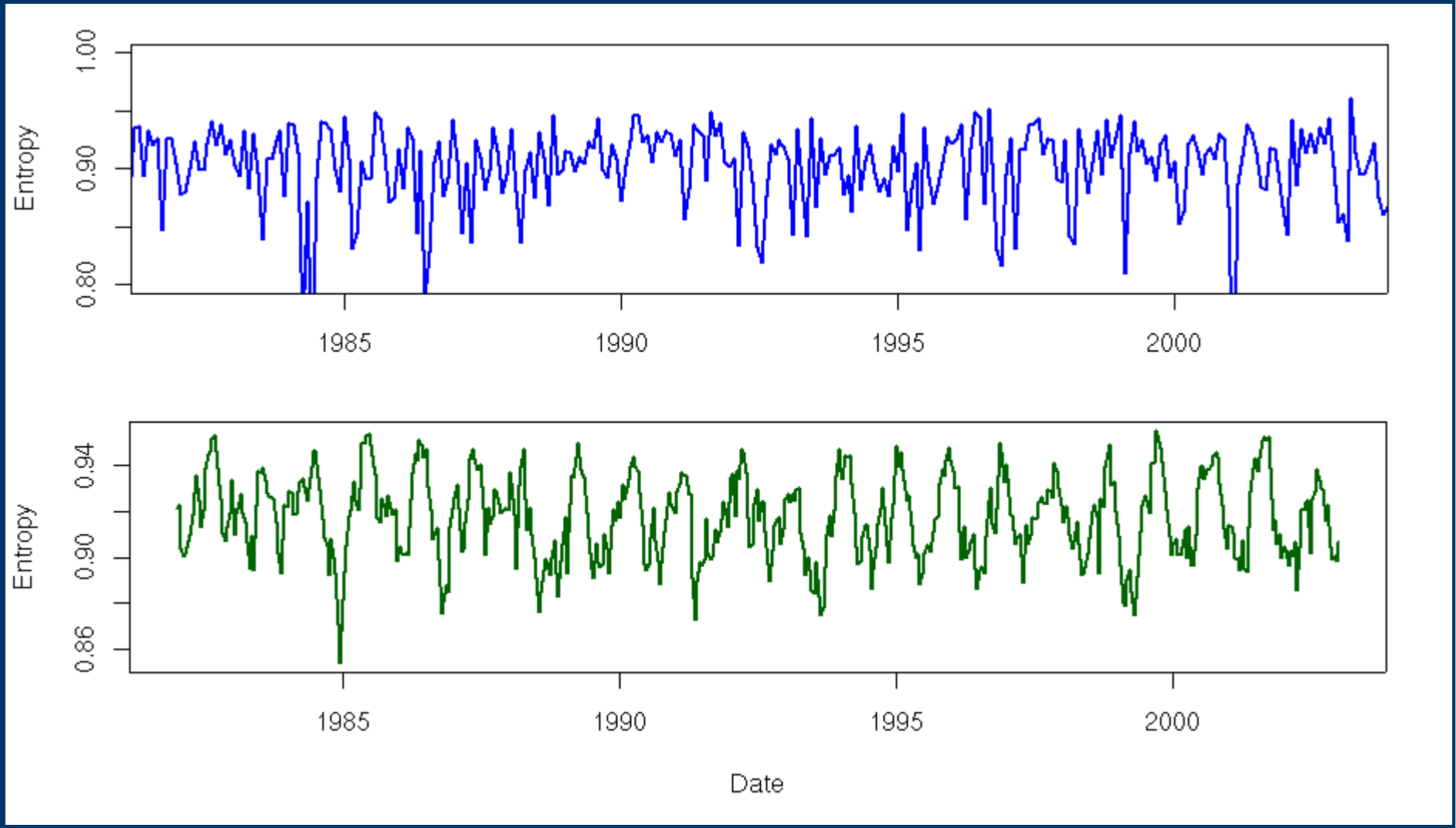
Reduces entropy (increases predictability)



Spatial Entropy

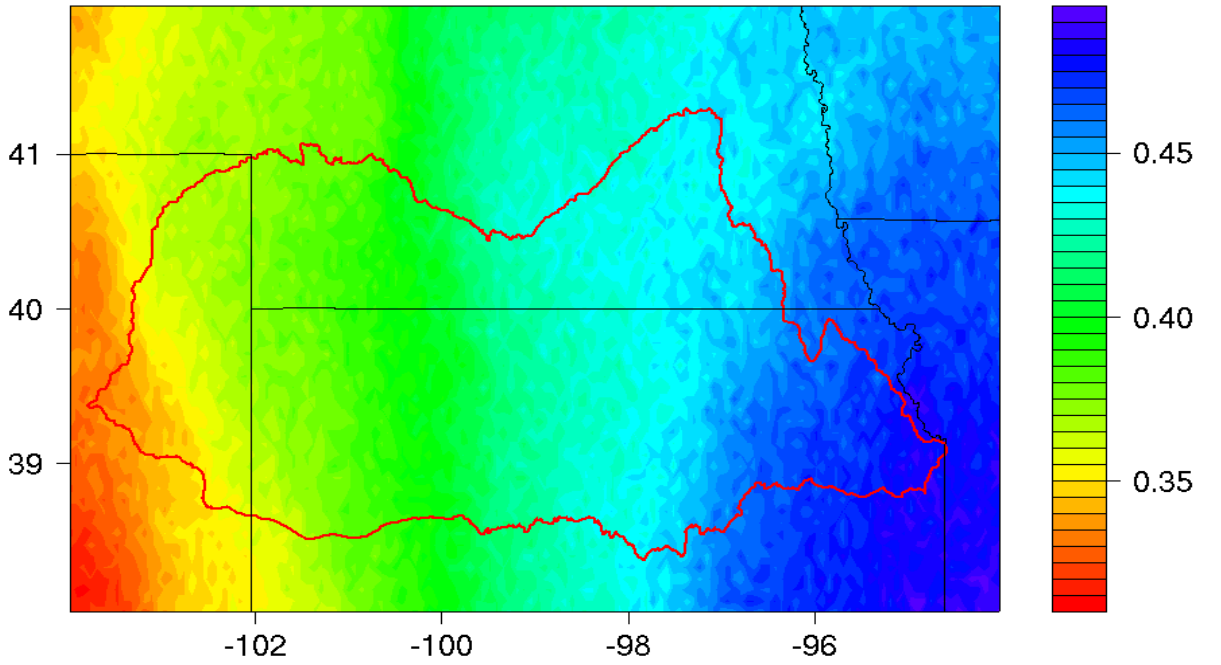
PPT

NDVI

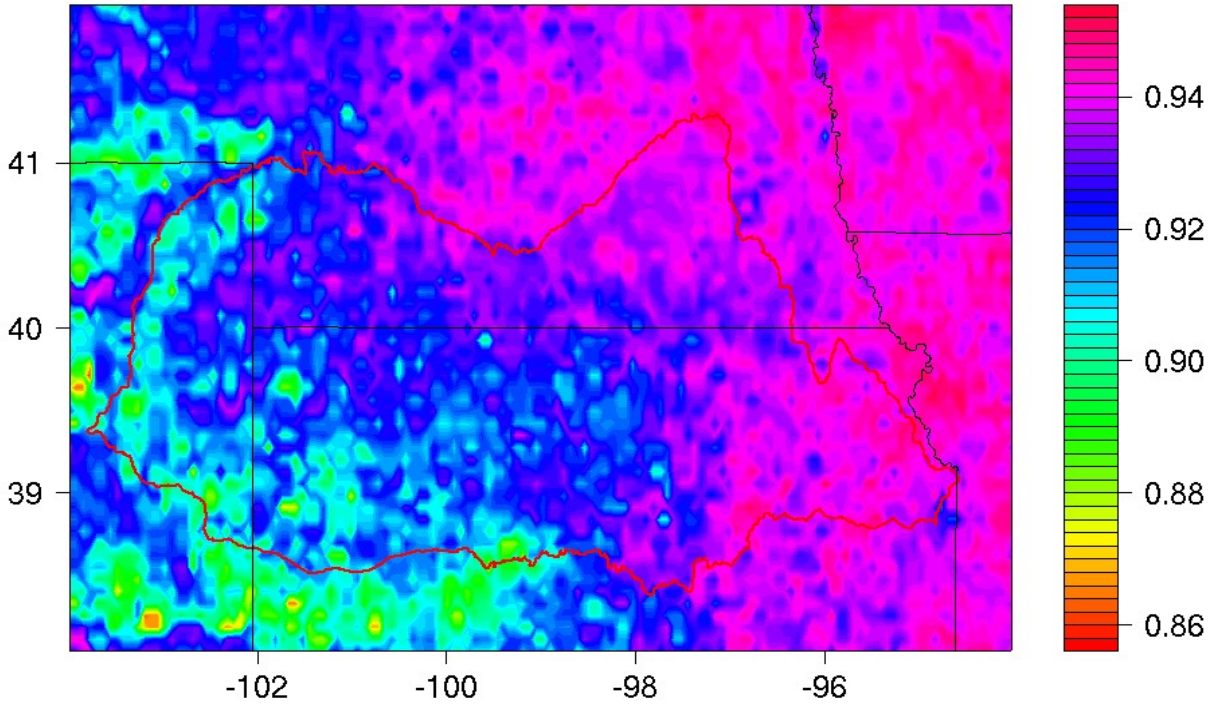


Temporal Entropy

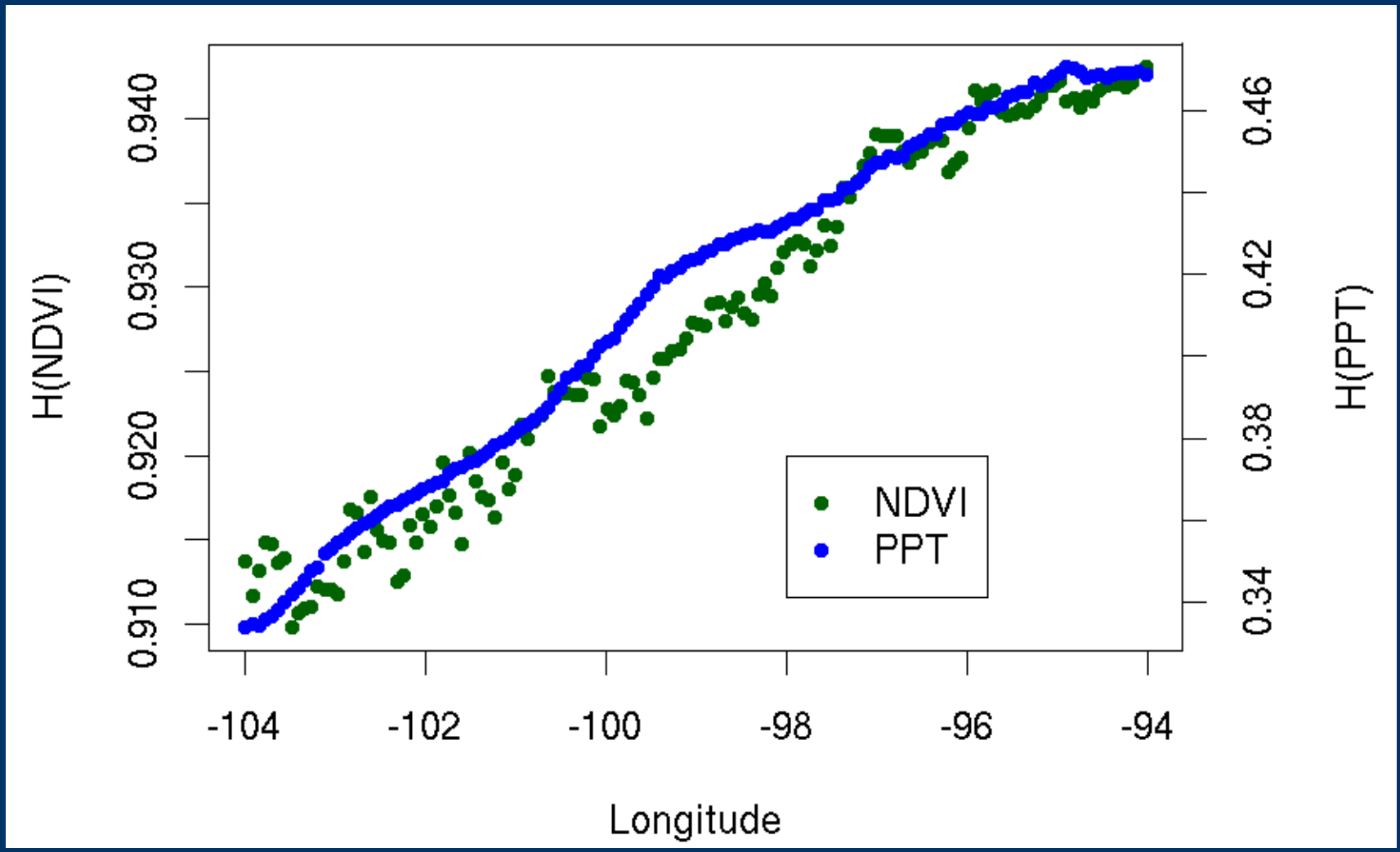
PPT



NDVI



Temporal Entropy



Summary

- Water and carbon cycles is difficult, but intricately linked at multiple spatial and temporal scales
- Understanding the spatial and temporal responses of vegetation to changes in precipitation regimes (and vice versa) is required for many applications
- Understanding the statistical distributions and information theory metrics provides a possible method for quantifying the predictability of the system